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BIOLOGY AND BEHAVIOR OF THE STRAWBERRY GUAVA SAWFLY, *HAPLOSTEGUS EPIMELAS* KONOW 1901 (HYMENOPTERA: PERGIDAE), IN SOUTHERN BRAZIL

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Abstract.—Results of four years of observation and study of the strawberry guava sawfly, *Haplostegus epimelas* Konow 1901, in two ecosystms, coastal plain and Paraná first plateau of Brazil, are presented. The strawberry guava sawfly is trivoltine, feeding almost exclusively on sprouting araçá, or strawberry guava, *Psidium cattleianum* Sabine (Myrtaceae). This plant is native to the Brazilian Atlantic forest but is currently found throughout the tropics where it is frequently a weed. Adult female sawflies are rarely found in the field and males have never been found. The eggs are laid when the sprouts are young. Larvae are gregarious and go through six or seven instars. Pupation occurs in the soil. Natural enemies attack all stages. The total parasitism frequency is 3.6%, mostly by *Vibrissina* sp. (Diptera: Tachinidae). Two main types of damage to strawberry guava are oviposition wounds resulting in the death of twigs and young leaves consumed or damaged by larval feeding. The sawfly completes its life cycle on strawberry guava but has recently been observed feeding on commercial guava, *P. guajava* L., which may preclude its use as a biological control agent.

Resumo.—São apresentados os resultados de quatro anos de observações e estudos sobre a vespa-serra, *Haplostegus epimelas* Konow 1901 (Hymenoptera: Pergidae) em dois ecossistemas: Litoral (Restinga) e Primeiro Planalto Paranaense. O dimorfismo sexual entre machos e fêmeas é distinto por três características morfológicas. A vespa-serra procria-se e alimenta-se na brotação sazonal do araçazeiro, *Psidium cattleianum* Sabine (Myrtaceae) e é trivoltina. Esta planta originalmente da Floresta Atlântica brasileira encontra-se distribuída nas regiões tropicais e subtropicais onde se tornou daninha. Fêmeas adultas da vespa-serra são raramente encontradas no campo e os machos nunca foram vistos. Os ovos colocados em brotações tenras. As larvas são gregárias e passam por 6–7 intares. O empupamento ocorre no solo. Há inimigos naturais em todas as fases do ciclo vital. O parasitismo por *Vibrissina* sp. (Diptera: Tachinidae) atinge 3, 6%, é o mais importante. Dois tipos de danos são encontrados: lesões nos ramos pelo ato de postura e os danos causados nas folhas jovens por larvas neonatas. A vespa-serra completa seu ciclo vital no araçazeiro e foi recentemente encontrada em goiabeira, *Psidium guajava* L. (Myrtaceae) fato que pode limitar o seu uso como um agente de controle biológico.

Key Words: araçá, biological control, biology, behavior, strawberry guava, sawfly

For almost two centuries, araçá or strawberry guava, *Psidium cattleianum* Sabine (Myrtaceae), has attracted the attention of horticulturists who have used it as an or-

namental plant and fruit tree. It has been introduced into several parts of the world, where it has spread aggressively competing with the local vegetation (Smith 1985). In its native Brazilian Atlantic forest, it grows harmoniously with the other vegetation of the woods. Two types of strawberry guava are known, one with red fruit and the other with yellow fruit. In Brazil, the red-fruited form is confined to higher elevations above 850 m, whereas the yellow-fruited form is found throughout the range. Elsewhere in the world, the two forms are found at all elevations. In its native woods, this tree can be of medium height (up to 5 m), but it has a low density per hectare (<1% cover). In contrast, the trees along roads, urban areas, and agricultural or pasture areas are abundant and bushy. Numerous natural enemies and competition from other plants effectively control strawberry guava in Brazil.

This study describes the biology of *Haplostegus epimelas* Konow, the associated phenology of strawberry guava, and the impact of the sawfly's damage on the plant. The objective is to evaluate the potential of the sawfly as a biological control agent in Hawaii. Some other insect species, mainly gall midges, are important natural enemies of strawberry guava (Wikler 1995, Vitorino 1995, Angelo 1997). A species of Coleoptera (Chrysomelidae) is also destructive, but it is not confined to strawberry guava (Caxambu 1998). According to Smith (1993), some Pergidae are considered forest pests in North and South America, New Guinea, and Australia. Benson (1940) and Smith (1990) reported that *H. epimelas* also attacks guava, *Psidium guajava* L., in the State of Pernambuco.

Material and Methods

Study area.—Field observations of the plant and sawfly were carried out in two regions: (1) First plateau of Paraná (48°58′ to 49°38′W; 25°27′ to 25°35′S), particularly the districts of Curitiba, Balsa Nova, Campo Largo, Almirante Tamandaré, Colombo, Piraquara, and São José dos Pinhais; and (2) the coastal plains of Paraná and Santa Catarina (Restinga) (48°29′ to 48°46′W and 25°19′ to 26°03′S) especially the districts of Antonina, Morretes, Paranaguá, Pontal do Paraná, Guaratuba, and the coastal plain of Santa Catarina (only the district of Itapoá). According to Carpanezzi et al. (1986), the first plateau of Paraná is characterized by altitudes from 650 to 1,100 m, and by a rain forest of *Araucaria angustifolia* (Araucariaceae) and submontane fields. Within the Holdridge system, the climate is temperate, hot and humid, or very humid. The average annual temperature ranges from 15° to 19°C, with an absolute minimum of −10°C. One to forty frosts occur per year. The average rainfall ranges from 1250 to 2500 mm and there is no water deficit. The coastal plains of Paraná and Santa Catarina are characterized by native rain forests of low altitude, ranging from 0 to 500 m. The climate is subtropical, humid or very humid, according to the Holdridge system. The average annual temperature ranges from 18° to 22°C, with an absolute minimum of −0.9°C. Frosts are rare. The annual rainfall ranges from 1,600 to 2,000 mm, and there is no water deficit.

Methodology.—All captured insects were taken to the nursery at the Forest Protection Laboratory, Federal University of Paraná, where they were kept alive for observation. Prepupae were kept in containers of two different sizes (3 × 7 cm, vol. 45 ml; 5 × 11 cm, vol. 180 ml) to study adult and parasite emergence and to record life history data, e.g., adult longevity, oviposition, depth of pupation, and pupal duration. Diameter of cocoons, period of oviposition, and number of eggs were measured on shoot tips or branches. The growth of strawberry guava was observed using 20 trees previously chosen at random and tagged, ten in the District of Colombo, Paraná (Estancia Betania), and ten from the District of Piraquara, Paraná (Mananciais da Serra Mar). The presence of adult sawflies, eggs, and larvae were counted and observed from September 1994 through July

1998. Standard statistical tests were used. Damage caused by oviposition and larvae were evaluated during a year of observations and collecting of field data.

Results and Discussion

Host plants and host specificity.—In the states of Paraná and Santa Catarina, *Haplostegus epimelas* was observed on yellow- (350) and red-fruited (25) strawberry guava plants during weekly visits to the field and in the University gardens. The red-fruited trees are not found in the coastal plains. In the two states cited above, there are several other Myrtaceae, such as *Psidium spathulatum* Mattos, *Campomanesia xanthocarpa* Berg., *Eugenia uniflora* L., *Eugenia involucrata* DC, *Myrciaria trunciflora* Berg., *Gomidesia schaueriana* Berg., and *Acca sellowiana* (Berg.) Burret. Sawfly eggs and larvae were not found on any of these trees.

Sawfly life history.—The female averages 10.2 ± 0.3 mm long (n = 13) and the male 8.3 ± 0.3 mm long (n = 15). Both the male and female are black dorsally with the ventral part of the head and the posterior part of the abdomen dark brown, the thorax orange, and the front legs orange to the tibiae with the tarsi almost black. The female is larger than the male; otherwise, the usual sexual characters separate them. In the field, the female is rarely observed on the plant, and males were never seen. To oviposit, the female turns upside down on young, soft branches to lay eggs. The diameter of these branches range from 2.1 to 3.9 mm (2.9 ± 0.1 mm) (n = 61). Ninety egg masses on 20 strawberry guava trees were observed. Only eight females were observed during oviposition. The eggs are laid in a line, under the epidermis of young shoots that are slightly reclined. Between each egg, there is a septum, a fiber filament of the vegetable tissue, which separates them (Fig. 1).

The number of eggs laid varies from 52 to 118, averaging 90.5 ± 16.4 per female (n = 13). As many as 178 eggs were found in the ovary of one virgin female, suggesting that they move to other branches to continue oviposition. The eggs are rod-shaped, with ovoid tips. Eggs are white from oviposition to eclosion. In the field, incubation lasts from 7 to 12 days with an average of 10 days (Fig. 2).

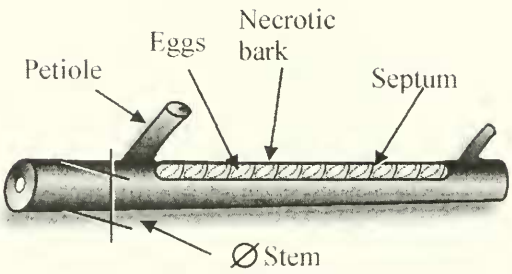

Fig. 1. Oviposition site of *Haplostegus epimelas*. Eggs are distributed symmetrically and reclined.

The gregarious, newly hatched larvae move to young, recently expanded leaves to feed. Initially, they feed by scraping the under surface of the leaf. Fourth instar larvae consume the entire leaf. In the last instars they remain gregarious, but they sometimes split up into smaller groups. When larvae are disturbed they bend the posterior part of their abdomen over their dorsum showing an attitude of intimidation. If they are touched, they regurgitate a drop of fluid which hangs from their mouths. The smell of the regurgitated substance is strong and similar to the smell of the host tissue on which they are feeding. Presumably, the fluid deters natural enemies. The growth of the larvae and the number of instars are not always homogeneous. Observations in the laboratory show that the gregarious habit of the larvae is vital for the survival of the larval colony. When a group of first instar larvae is smaller than ten, they die before completing their larval development. Larvae were observed to go through 6 or 7 instars. Growth of some larvae are delayed in relation to others from the same egg batch. As a consequence, they go through at least one additional instar. When they reach the end of the larval period, the larvae are 22.1 ± 0.7 mm long (n = 15). They stop feeding and start draining their diges-

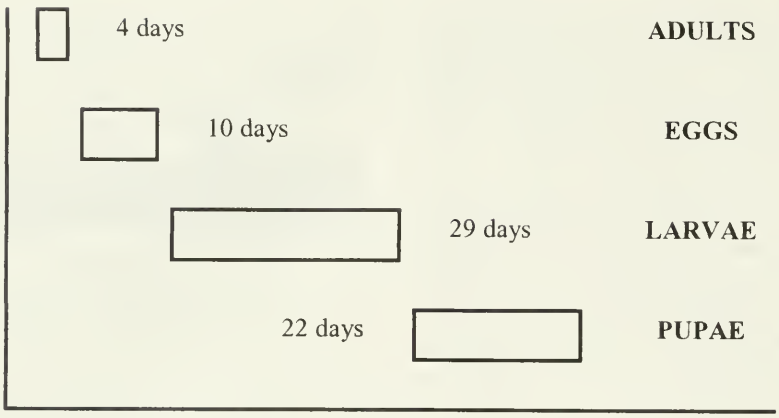

Fig. 2. Life cycle of *Haplostegus epimelas*.

tive tube, changing their tegument and their head capsule. The last exuvium is larger than the previous one and is adhesive and sticky to the touch. It loses its adhering property when it dries out.

The prepupa is 11.8 ± 0.4 mm long (n = 12). The dorsum is light brown and the venter is light beige; the head and the endo of the abdomen are black. It is easy to see that there is nothing in the prepupa intestine. Its body is thinner and shorter compared to that of the full-grown larva. The prepupa drops off the branch and digs into the organic soil within one hour, taking advantage of natural depressions or holes. The average depth of penetration in sandy soil is 20.3 ± 3.6 mm (n = 12) as measured from pupae inside plastic containers. After penetrating the soil, the prepupa produces silk to form a cocoon in which it remains free for a variable time. After a few hours, some prepupae lose the capacity to penetrate the soil and become stiff, getting infected by fungi. The male cocoon is 7.7 ± 0.2 mm long (n = 12) and has a diameter of 4.3 ± 0.2 mm (n = 12). The female cocoon is 8.8 ± 0.1 mm long (n = 20) and has a diameter of 5.0 ± 0.2 (n = 20). The cocoon is spun with white, thin, soft silk fibers, but, in the soil or sand, it later becomes dark and stiff. Particles of soil or sand adhere to it, making it look bigger than it actually is. For males, the average pupation period is of 21.5 ± 1.0 days (n = 51). For females, it is 21.6 ± 1.5 days (n = 24). From 330 prepupae, 75 (51 males and 24 females) *H. epimelas* adults emerged, 6 adults of another sawfly (*Truqus magnus* Smith 1990, Hymenoptera: Pergidae, identified by D. R. Smith) emerged, and parasites emerged from 12 others. For unknown reasons, 237 pupae (71.8%) died during the pupation period. The larvae of *Truqus magnus* were found in Mananciais da Serra in Piraquara, Paraná, on the yellow-fruited strawberry guava and in the neighborhood of Santa Felicidade, Curitiba, Paraná, on the red-fruited strawberry guava. Smith (1990) described the species from samples collected in Campina Grande do Sul, Paraná, northern Curitiba.

Adult females oviposit and live for 2 to 3 days in the laboratory according to Pedrosa-Macedo (1998). No maternal behavior was observed. The larval phase is generally between 28–30 days; however, some feed up to 35 days (Fig. 2). The prepupal phase, inside a cocoon, has variable longevity. They can remain in the soil for several weeks. We have observed three peaks in *H. epimelas* populations for two years, suggesting that it is trivoltine (Fig. 3).

Natural enemies.—The main parasitoid of *H. epimelas* is an undetermined species of *Vibrissina* (Diptera: Tachinidae). There are also two other species of the family Sar-

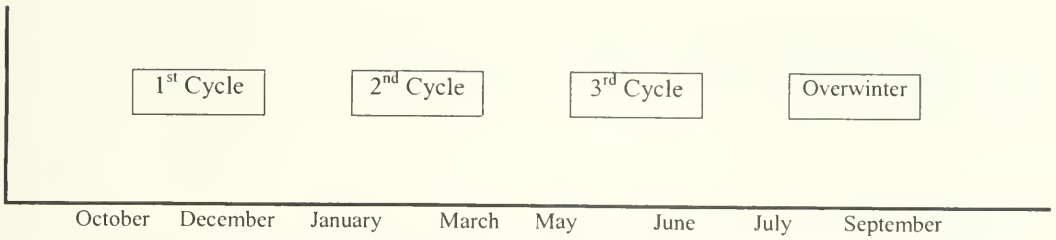

Fig. 3. Annual seasonal activity of *Haplostegus epimelas*, 1997 to 1998.

cophagidae (Diptera). These parasites emerge from the cocoon after an average of 28.3 ± 0.9 days (n = 12) after pupation of the host. The percentage of parasitism recorded was 3.6% (n = 330).

One mite egg predator was observed. Its presence was recorded in November 1997 at Mananciais da Serra, Piraquara, Paraná. One female adult sawfly was found caught in a spider web. The fungi *Fusarium* sp. and *Verticillium* sp. were isolated from dead prepupae, but it is not known if they were responsible for deaths.

Damage.—Three types of damage are caused by the sawfly on young shoots of strawberry guava. The first and most important for biological control is the wound caused by the female during oviposition. The second is by the young larvae (first to third instars) which scrape the underside of young and soft leaves on the same sprout as the egg mass. The third is by the fourth to seventh instar larvae which eat mature leaves entirely elsewhere on the plant. The female destroys the soft tissue of the shoots when penetrating their epidermis with her saw-like ovipositor. The action of the young larvae further injures the young shoots resulting in the death of 31% of the shoots (28 of 89 observations) leaving 69% of the shoots alive. When the first and second types of damage occurred together, they caused irreparable loss to the strawberry guava, which survived but had permanent damage, i.e., the branches were bent.

The activity of the sawfly is synchronized with flushing of the strawberry guava. The sprouts on the branches are abundant in the spring and summer. In autumn, new sprouts can be seen, but in winter they are scarce. Therefore, there are sprouts on the strawberry guava which enable the survival of sawflies in all four seasons of the year. Nevertheless, in the coast and plateau regions, there was a period of 120 ± 7.9 days (n = 3, June 1995 to July 1998) in which no adult sawflies, eggs, or larvae were found.

Use as a biological control agent.—The pupal phase of *Haplostegus epimelas* is easy to transport or export. A 45 ml capacity container (3 × 7 cm) is adequate for handling and exporting pupae. The natural enemies of the sawfly contribute to their population balance, but they do not limit the impact and damage caused to the plant. Unfortunately, the sawfly has recently been observed attacking two plants of *Psidium guajava*. This observation, though perhaps an unusual even, may curtail an attempt to use this species as a biological control agent.

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